IONOSPHERE COLLECTION CAPABILITY FROM A 3U CUBESAT GNSS-RO CONSTELLATION

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SPIRE GLOBAL, INC.

- Leading player in nanosatellite sector
- Building the most advanced, constantly refreshed 3U satellite constellation
- Vertically integrated: design, build, launch, operate, and process data from 3U CubeSats
- Offices in Glasgow, Singapore, San Francisco, and Boulder
- Providing rapidly refreshed data:
  - AIS (i.e., ship tracking)
  - ADS-B (i.e., commercial aviation tracking)
  - GNSS Radio Occultation (RO)
    - Neutral: temperature profiles from 0 to ~ 60 km, assimilation into weather models
    - Plasma: Electron Density Profiles, scintillation indices, TEC

Satellite Production (up to 12 at once)

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NOAA CWDP

- Spire recently selected to participate in a NOAA Commercial Weather Data Pilot (CWDP)
- First pilot of its kind
- Demonstrate data quality and potential value to NOAA's weather forecasts and warnings
- Marked new era of public / private partnership

SHARE

162

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12

Spire has 12 shoebox-sized Lemur satellites in low-Earth orbit. Spire

NOAA issues first contracts for private weather satellites

By Paul Voosen | Sep. 16, 2016 , 1:45 PM

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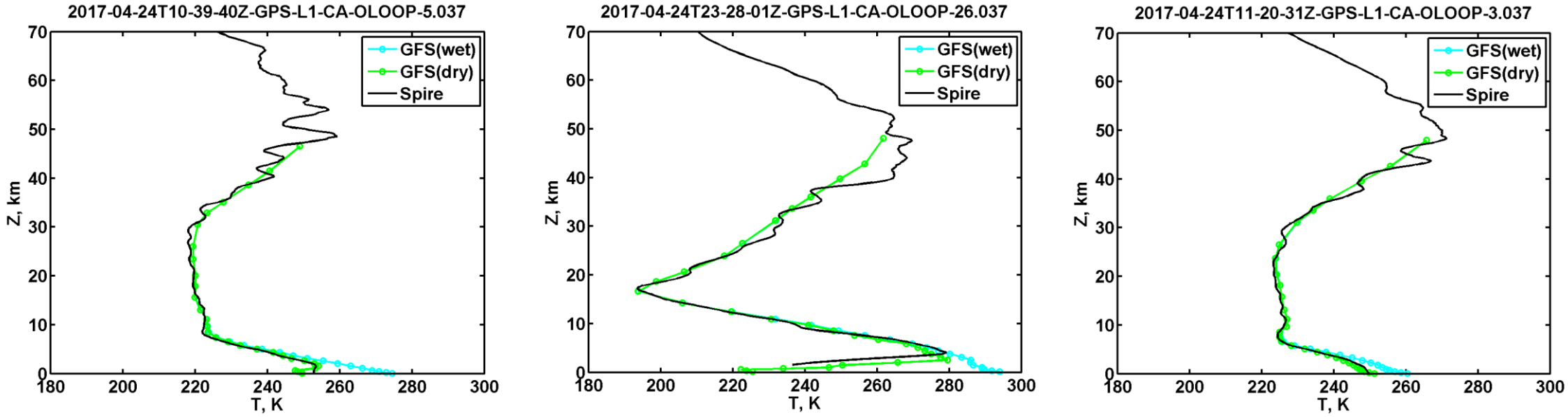
NOAA CWDP (cont.)

- Successfully launched, collected, processed, and delivered RO profiles to NOAA
- Demonstrated feasibility of supplying high quality, commercial data to NOAA within a 3U CubeSat

Example neutral profiles recently collected from Spire's GNSS-RO constellation



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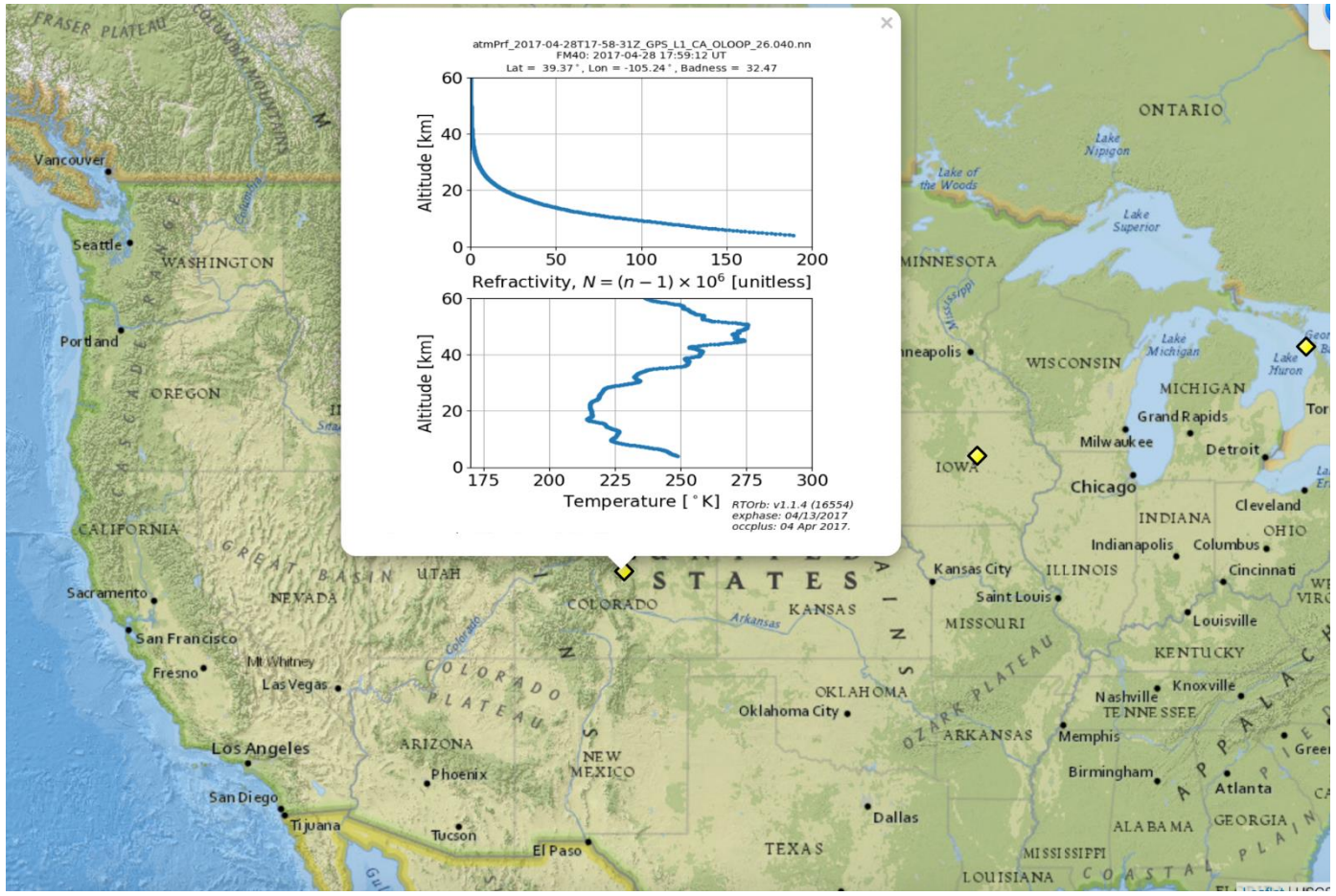
NOAA CWDP (cont.)



- Recent inversion near Boulder (< 50 miles) from 2017-04-28

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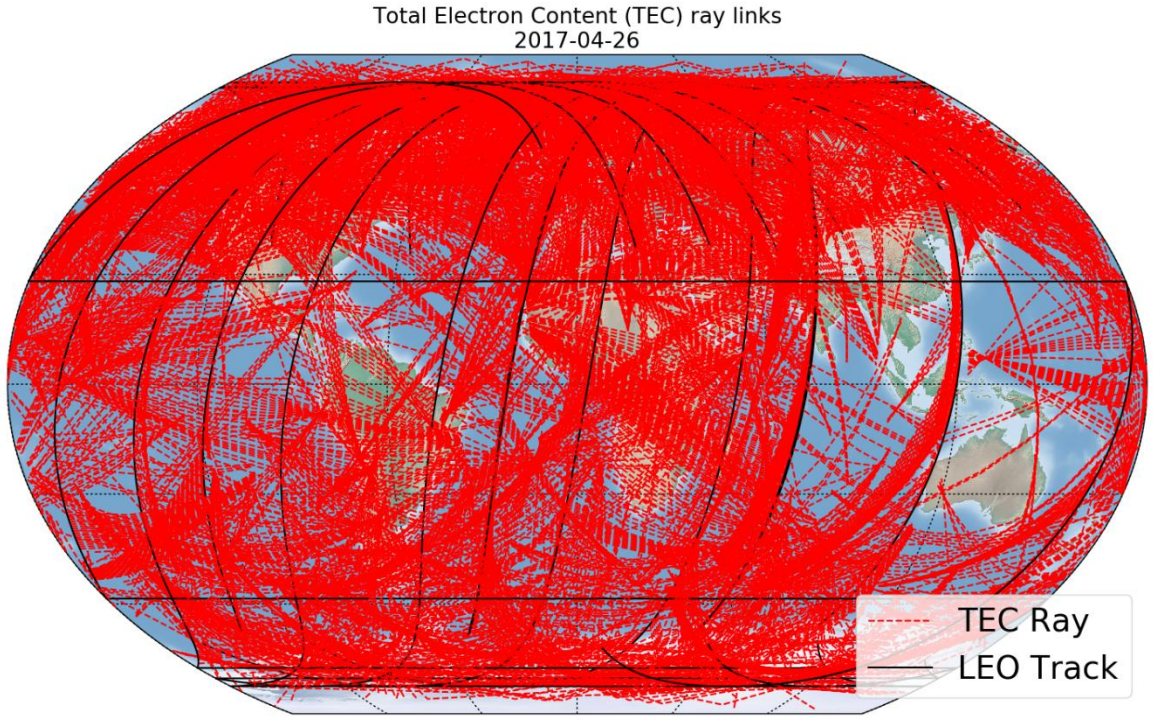
IONOSPHERIC CAPABILITY

- In addition to producing high quality neutral measurements, Spire's 3U constellation records information about the plasma state:
  - Electron density profiles
  - Line of Sight (LOS) Total Electron Content (TEC) measurements
  - Scintillation indices (S4, sigma phi)



LOS TEC tracks from data collected in 24 hours

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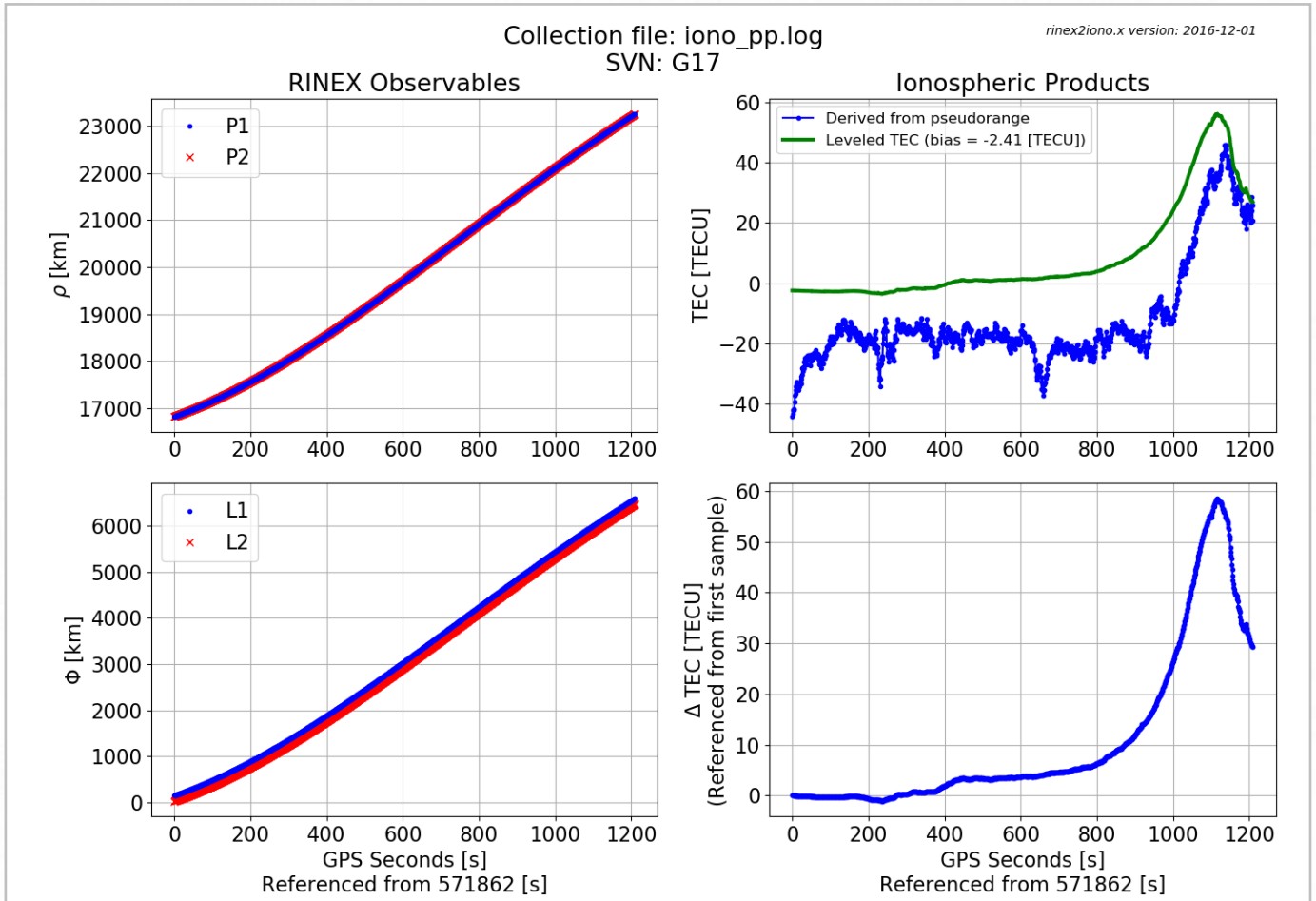
IONOSPHERIC CAPABILITY

- Example data collected throughout NOAA Trial (~ 5 weeks)

Total TEC data points	636,509
Total scintillation data points	164,290



Example TEC data collected from a Spire 3U CubeSat

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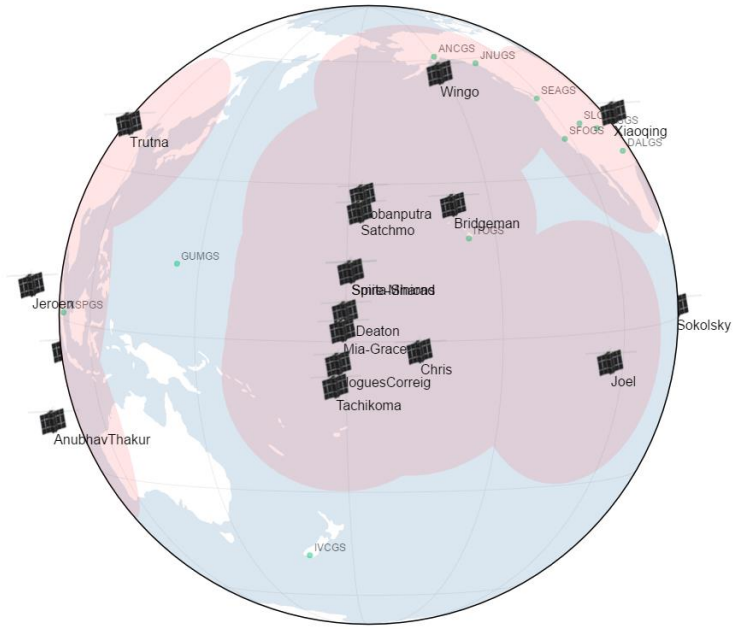
FUTURE CAPABILITY

- Spire is quickly growing its constellation capacity for both RO and Ionospheric measurements
- Consider a 60 satellite constellation with 50% duty cycle
- How many ionospheric measurements can we make in 1 day?



Spire Today: Global and Continuous Coverage

$$86400\ \text{sec} \times 60\ sats \times 4\ GNSS\ links \times 1\ \text{TEC meas. per sec} \times 50\%\ \text{duty cycle}$$

$$= \sim \mathbf{10\ million\ TEC\ measurements\ per\ day}$$

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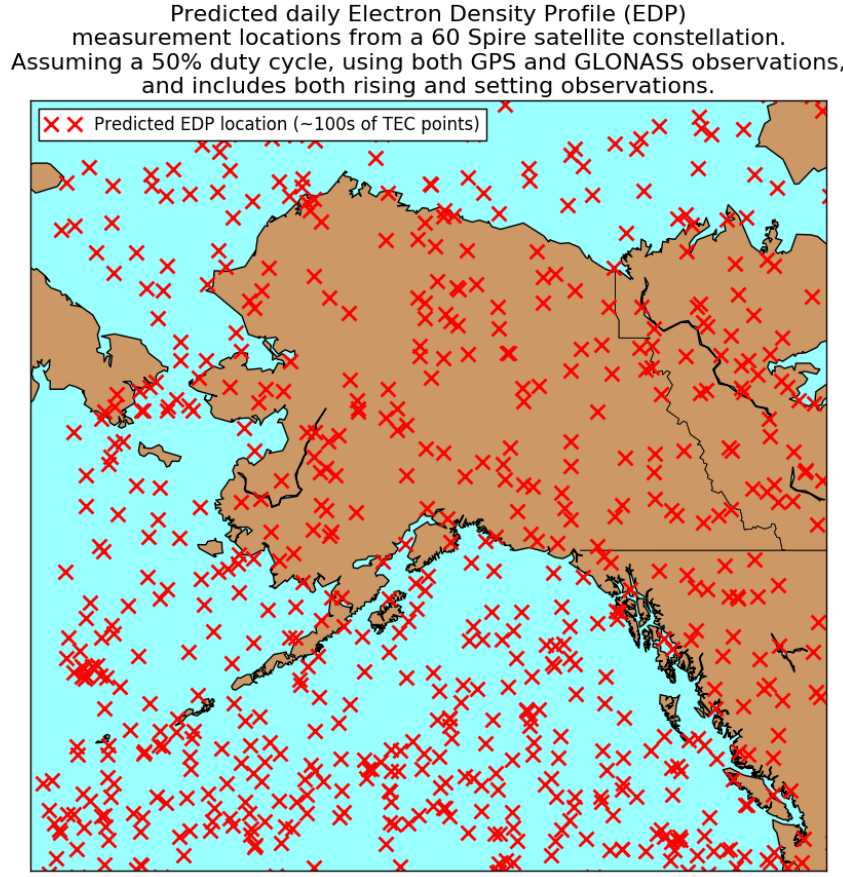
IONOSPHERIC COVERAGE

- Again, consider a 60 Spire satellite constellation with 50% duty cycle
- Simulation of predicted electron density profile locations over one day
- Unprecedented coverage of electron density profiles



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CONCLUSION AND FUTURE OUTLOOK

- Exciting times for commercial RO in terms of both neutral and plasma characterization
- In a short time frame, Spire will have potential for rapidly refreshed measurements of the ionosphere in near real time
- Has major implications for space weather, communications, and fundamental plasma physics

Deployment of two Spire 3U CubeSats from the ISS

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